

REMARKS

Claims 25-38 stand rejected in the Office Action. Claims 20-24 have been withdrawn from consideration in response to the Restriction Requirement and are canceled with this amendment. Claims 25, 28, and 32 have been amended in this Response, while new claim 39 is offered. Upon entry of the amendments, claims 25-39 remain pending in the Application.

Claim 28 has been amended to correct claim dependency. Support for the Amendment to claim 25 is found in the specification as originally filed, for example on page 3, lines 14-17 and on page 7, lines 10-17. Support for the amendment to claim 32 is also found in the passages supporting the Amendment to claim 25. Support for new claim 39 is found in the specification, for example on page 6, lines 10-12. Applicants respectfully request entry of the amendments.

CLAIM OBJECTIONS

Applicants have corrected the dependency of claim 28, as suggested by the Examiner. It is believed that the amendments to claim 28 suffice to remove the claim objection.

REJECTION UNDER 35 U.S.C. § 102

Claims 25, 29, 30, 31 and 32 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Dash (U.S. Pat. No. 2,491,479).

The Examiner states that the Dash reference shows arc welding an aluminum stud to an aluminum plate. The Examiner further asserts that, since the aluminum alloy is taught as containing 0.2% titanium, the titanium would inherently comprise the surface of the stud. Applicants respectfully traverse the rejection as applied to the amended claims and request reconsideration.

Applicants have amended claim 25 and 32 to more clearly define the invention. In particular, Applicants have added language supported by the specification that the titanium on the surface on the head of the aluminum weld stud is provided in the form of a layer of titanium containing material. Such a limitation is not present in the Dash reference—as noted above, the Dash reference teaches the titanium is merely part of the aluminum alloy, and is not present as a layer on the surface. Rejected claims 29-31 depend from claim 25 and so include the limitation that the titanium containing material is present as a layer on the surface of the stud. Because the amended claims contain at least one element or limitation not found in the Dash reference, they are patentable over the Dash reference under § 102. Accordingly, Applicants respectfully request that the rejection of claims 25, 29, 30, 31, and 32 over the Dash reference be withdrawn.

REJECTION UNDER 35 U.S.C. § 103

Claims 26-28, and 33-38 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the Dash reference as applied to claims 25 and 32, and further in view of Martin (U.S. Patent 2,670,424) and Konnert (U.S. Patent 4,326,894). The Martin reference appears to be cited for a teaching of a weld stud coated with titanium, and the Konnert reference appears to teach applying a titanium material to a surface by using an acidic solution comprising titanium ions. The Office Action states that the teachings of the Martin reference and the Konnert reference make-up for the deficiency of the Dash reference, which does not disclose applying a coating to a stud surface with an acidic solution. Applicants respectfully traverse the rejections and respectfully request reconsideration.

For a rejection of claims over a combination of references under § 103, the references when combined must teach or disclose every element of the claims. Further, there must be a

motivation to combine the teachings of the references in order to arrive at the subject matter of the claims. Just because references can be combined to arrive at the claimed subject matter, such combination is not obvious unless there is a suggestion that it would be desirable to do so. In assessing the teaching of cited references, it is appropriate to consider the entire teaching of the references and the interpretation a person of skill in the art would apply to those teachings. In particular, portions of the reference that teach away from making the combination should be considered in determining whether the invention as a whole would have been obvious to a person of skill in the art.

As noted above, the Dash reference does not disclose a layer of titanium on an aluminum weld stud, as recited by the amended claims 25 and 32. Accordingly, these and other features of claims 26-28 and 33-38 must be supplied by the cited references Martin and Konnert. Dash discloses an aluminum stud, but it does not teach a coating of titanium on the stud.

The Martin reference teaches away from coating an aluminum stud with titanium. Martin is drawn to the welding of steel or steel alloy studs to plates made of steel. Column 1, line 12-14. Aluminum is preferred for metallizing a steel stud, but other alloys having the required characteristics may be used depending on the material the stud is made of. Column 3, lines 9-13. The required characteristics include that the metal for metallizing the (steel) surface of the stud have a higher conductivity than the stud material. Column 2, lines 42-45.

In the current claims, on the other hand, the metal (titanium) forming a coating on the studs has a lower conductivity than the stud metal (aluminum). Thus, while Martin teaches aluminum is preferred to put on an iron or steel stud, it specifically teaches away from using a poorly conductive metal, such as titanium, to coat a highly conductive material such as aluminum.

The relative conductivities just mentioned are well-known and can be looked up in standard treatises. For example, it is known that aluminum is more conductive than iron or steel, and that titanium is less conductive than aluminum. Attention is respectfully drawn to the attached web page from the Newsletter of the American Metal Market, available at www.amm.com. The relative conductivity of aluminum (based on copper as 100) is given as from 39-59 while the relative conductivity of titanium is given as 5 and that of steel is given as 3-15. Thus, the conductivity of the titanium is nearly an order of magnitude lower than that of aluminum. The conductivity measurements in the table are consistent with values of resistivity available in standard treatises such as the attached pages from the Metal Handbook, 8th Edition, published by The American Society for Metals. The electrical resistivity of titanium is given as 42 microhm-cm, while the resistivity of aluminum is given as 2.6548 microhm-cm. Because the electrical resistivity is the reciprocal of the electrical conductivity, the Metals Handbook data show the electrical conductivity of titanium is more than an order of magnitude less than the conductivity of aluminum.

Other passages in the Martin reference do not reverse the express teaching away from titanium on aluminum. The Martin reference teaches that is preferred to metallize a steel stud with aluminum, but does indicate that other metals may be placed on studs made of other materials. However, the reference is very clear to state that other metals or alloys chosen for the metallization must have the required characteristics (column 3, lines 11, discussed above). Since the required characteristics include a metal having a higher conductivity than the material of the stud, this amounts to an express teaching that metals of low conductivity (such as titanium) are to be avoided when using a highly conductive material such as aluminum for the stud.

Further, the Martin reference states that there is “no limitation...as to the specific metallizing materials”. Column 4, lines 38-40. But these lines directly contradict the earlier teaching that metals must have required characteristics, including higher conductivity than the stud material. Because even the claims of the reference recite the “higher electrical conductivity” feature of the metallizing material, the person of skill in the art would discount the statement that there is no limitation. The reference at Column 4 goes on to suggest for the use with steel or steel alloy studs, other metals such as titanium, manganese, and vanadium can be used. But this is no teaching to coat an aluminum stud with titanium. In light of the reference’s express teaching against combining titanium with an aluminum stud, Applicants respectfully submit that the reference at Column 4 does not motivate one of skill in the art to modify the disclosure of the Dash to arrive at the subject matter.

The Konnert reference does not overcome the deficiencies of the Dash and Martin references as just discussed. The Konnert reference is directed to preparing conversion coatings. The reference simply does not motivate one of skill in the art to apply a titanium coating to an aluminum stud in light of the teachings of the Martin reference discussed above. For this reason, Applicants respectfully submit that there is no motivation to combine the references.

For the reasons discussed above, Applicants respectfully submit the amended claims are patentable over the cited references. Accordingly, Applicants respectfully request the rejection be withdrawn.

Claim 39 adds a further limitation that distinguishes the claimed invention from the cited references. None of the references alone or in combination teach or suggest providing a (titanium) layer of sufficient thickness to prevent formation of aluminum oxide on the stud. For this and the reasons discussed above, Applicants believe claim 39 is patentable over the cited

references.

CONCLUSION

It is believed that all of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. Applicant therefore respectfully requests that the Examiner reconsider and withdraw all presently outstanding rejections. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance. Thus, prompt and favorable consideration of this amendment is respectfully requested. If the Examiner believes that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at (248) 641-1600.

Respectfully submitted,

Dated: January 28, 2004

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RMS/MAF/cg

Electrical Conductivity of Metals

This page is best viewed in Netscape 2.0+ or other table-capable browsers.

The table originally appeared in AMM's annual *Metal Statistics* book.

Metal	Relative Conductivity*	Temperature Coefficient of Resistance**	Tensile Strength (lbs./sq. in.)	Composition of Earth's Crust (% by Weight)
Aluminum (2S; pure)	59	0.0039	30,000	8.1
Aluminum (alloys):				
• Soft-annealed	45-50	—	—	—
• Heat-treated	30-45	—	—	—
Brass	28	0.002-0.007	70,000	—
Cadmium	19	0.0038	—	.0001
Chromium	55	—	—	.02
Climax	1.83	0.0007	150,000	—
Cobalt	16.3	0.0033	—	.002
Constantin	3.24	0.00001	120,000	—
Copper:				
Hard drawn	89.5	0.00382	60,000	—
• Annealed	100	0.00393	30,000	.007
Everdur	6	—	—	—
Gold	65	0.0034	20,000	.0000005
Iron:				
• Pure	17.7	0.005	—	5.0
• Cast	2-12	—	—	—
• Wrought	11.4	—	—	—
Lead	7	0.0039	3,000	.002
Magnesium	—	0.004	33,000	2.1
Manganin	3.7	0.00001	150,000	—
Mercury	1.66	0.00089	0	.00005
Molybdenum	33.2	0.004	—	.001
Monel	4	0.002	160,000	—
Nichrome	1.45	0.0004	150,000	—
Nickel	12-16	0.006	120,000	.008
Nickel silver (18%)	5.3	0.00014	150,000	—
Phosphor bronze	36	0.0018	25,000	—
Platinum	15	0.003	55,000	.0000005
Silver	106	0.0038	42,000	.00001
Steel	3-15	0.004-0.005	42,000-230,000	—
Tin	13	0.0042	4,000	.004
Titanium	5	—	50,000	.4
Titanium, 6Al4V	5	—	130,000	—
Tungsten	28.9	0.0045	500,000	.007
Zinc	28.2	0.0037	10,000	.01

* At 20° Celsius, based on copper as 100.

** Per degree C at 20° C.

Note: The conductivity of various metals is subject to variation according to processing and alloy composition.

(LEFT) A single crystal of antimony, cleared and deeply etched by an acid mixture along (111) planes (Bell Telephone Laboratories, Inc.). (RIGHT) Sahara desert sand dunes in southern Libya (Aero Service Corp.).

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name.

The adjectives electric
the following senses. Electr
arising from, actuated by,

Electric currents in metals are caused by mobile, relatively free electrons that are not bound to any particular atom and can wander throughout the metal. In general, the conductivity of metals is higher than that of other materials, and decreases with rising temperature. At temperatures near absolute zero, certain metals become superconductors, possessing infinite conductivity. For an extended discussion of this phenomenon, see **SUPERCONDUCTIVITY**. The conductivities of a number of common metals at 0°C are as follows:

<i>Metal</i>	<i>Conductivity,</i> <i>(ohm-meter)⁻¹</i>
Silver	66
Copper	64.5
Gold	49
Aluminum	40
Magnesium	25.4
Sodium	23.4
Tungsten	20.4
Potassium	16
Lithium	11.8
Iron	11.5
Cesium	5.2

Few developments have American life than Morse paved the way for the first communication, the telegraph, the telephone and later to the radio. The growth of electrical engineering, the development of electrical equipment, and the birth of the automobile, adding much to the wealth of the nation at the same time making possible the industrial revolution throughout the nation.

METALS HANDBOOK

8th Edition

VOL. 1

Properties and Selection of Metals

*prepared under the direction of the
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Metals Park, Ohio

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PURE METALS

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Aluminum (99.996%)

Compiled by A. W. DEMMLER, JR.*

- C 1 *Density*. At 68 F (20 C), 2.6989 g per cu cm (0.09751 lb per cu in.); at 77 F (25 C), 2.6978 g per cu cm (0.09747 lb per cu in.)
- D 2 *Melting point*. 1220.4 F (660.2 C)
- 4 *Boiling point*. 4442 F (2450 C)
- 6 *Thermal expansion*.

Temperature range, C	Average coefficient, micro-in./in./°C
-200 to 20	18.0
-150 to 20	19.9
-100 to 20	21.0
-50 to 20	21.8
20 to 100	23.6
20 to 200	24.5
20 to 300	25.5
20 to 400	26.4
20 to 500	27.4

- range between $\lambda = 2200$ and 2500 \AA ; 96% for $\lambda = 10,000 \text{ \AA}$ (1 micron); 97% for $\lambda = 11,000$ to $100,000 \text{ \AA}$ (1.1 to 10 microns)
- 5 *Emissivity* at 77 F (25 C). 0.030 in air
- G 2 *Magnetic susceptibility*. 0.6×10^{-6} cgs
- J 1 *Crystal structure*. Face-centered cubic; $a = 4.0491 \text{ \AA}$
- K 1 *Mechanical properties*. Modulus of elasticity, 9,000,000 psi

Property	Annealed	Cold rolled 75%
Tensile strength, psi ...	6,800	16,300
Yield strength, psi	1,700	15,400
Elongation, % (a)	60	5
Brinell hardness (b) ...	17	27

(a) Sheet specimens.
(b) 500-kg load, 10-mm ball.

Antimony

Compiled by K. C. Lit

- 11 *Specific heat* at 212 F (100 C). 0.224 cal per g
- 13 *Latent heat of fusion*. 94.5 cal per g
- 18 *Heat of combustion*. 7420 cal per g to $\alpha\text{Al}_2\text{O}_3$ at 77 F (25 C)
- E 1 *Electrical conductivity*. 64.94% IACS
- 2 *Electrical resistivity* at 68 F (20 C). 2.6548 microhm-cm
- 5 *Temperature coefficient of electrical resistivity*, 68 F (20 C). 0.00429 per °C
- F 1 *Reflectivity*. 90% for white light from a tungsten filament; 86 to 87% in

*Aluminum Co. of America

†President, Wah Chang Corp.

- 6 *Thermal expansion* 68 to 140 F (20 to 60 C). 0.0000085 to 0.0000108 per °C, the value depending on the crystal orientation in the polycrystalline material.
- 11 *Specific heat* at 68 F (20 C). 0.049 cal per g
- 13 *Latent heat of fusion*. 38.3 cal per g
- 15 *Latent heat of vaporization*. 373 cal per g
- 16 *Thermal conductivity*. 0.045 cal/sq cm/cm/sec/°C
- E 2 *Electrical resistivity* at 32 F (0 C). 39.0 microhm-cm
- F 1 *Reflectivity*. 70% at $\lambda = 5890 \text{ \AA}$
- G 2 *Mass magnetic susceptibility*. -0.87 cgs
- I 2 *Resistance to specific agents*.

Corrosive agent	Resistance
Air	Moderate general attack when air is moist and light is present

Alkalis and alkali salts	General attack
Ammonia	Resistant
Aqua regia	Severe general attack
Carbon dioxide	Resistant
Chlorine	Severe general attack
Hydrochloric acid	Moderate attack in presence of air
Hydrofluoric acid	Resistant
Nitric acid	Severe general attack
Sulfuric acid	Severe general attack by warm concentrated acid; resistant to cold or dilute acid

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Titanium (99.9%)

Compiled by W. STUART LYMAN*

- dissociation pressure. It is also used as a deoxidant and in electronic tubes and lamps for controlling starting voltages and maintaining stability.
- 2 **Precautions in use.** Thorium is a reactive metal and, depending on its chemical and physical form, is potentially toxic chemically and radiologically.
- C 1 **Density at 77 F (25 C).** X-ray: 11.72 g per cu cm; bomb-reduced (as cast): 11.5 to 11.6 g per cu cm; arc-melted iodide: 11.66 g per cu cm
- D 1 **Melting point.** 3182 F (1750 C)
- 4 **Boiling point.** 6332 to 7592 F (3500 to 4200 C)
- 6 **Thermal expansion (linear), 77 to 1832 F (25 to 1000 C).** 12.5 micro-in. per in. per °C (iodide thorium)
- 13 **Latent heat of fusion.** <4800 cal per mol
- 15 **Latent heat of vaporization.** 130,000 to 145,000 cal per mol
- 16 **Thermal conductivity at 212 F (100 C).** 0.090 cal/cm/sec/°C
- E 2 **Electrical resistivity at 273 K.** 13 microhm-cm
- 5 **Temperature coefficient of electrical resistivity, 32 to 212 F (0 to 100 C).** 0.0038 per °C
- 15 **Hall coefficient.** -8.8×10^{-5} cu cm per coulomb
- F 4 **Color.** Silvery white
- G 2 **Mass magnetic susceptibility at 90 K.** 0.66×10^{-6} emu per g
- I 1 **General resistance to corrosion.** Reacts readily in air and rather slowly in water (at 212 F). Below 1650 F, thorium is resistant to most liquid metals, with the exception of aluminum. Up to 1472 F, it is notably resistant to sodium-potassium.
- J 1 **Crystal structure.** Face-centered cubic up to 2552 F (1400 C), $a = 5.08$ kX; body-centered cubic above 2552 F.
- K 1 **Mechanical properties.** Average properties of as-cast, bomb-reduced thorium: tensile strength, 31,700 psi; yield strength, 20,900 psi; elongation, 34%; reduction in area, 35%; Vickers hardness (arc-melted iodide), 32 to 42; modulus of elasticity, 7 to 10 million psi. See table.

Tensile Properties of As-Cast Bomb-Reduced Thorium(a)

Value	Tensile strength, psi	Yield strength, psi	Elongation in 1 in., %	Reduction in area, %
Max	48,800	30,100	58	56
Min	23,900	13,800	8	7
Avg	31,700	20,900	34	35

(a) 0.02 to 0.08% C. Yield strength, 110 samples tested; other properties, 107 samples tested.

Source: G. Murphy, R. T. Othmer and R. E. Uhrig, Ames Laboratory, Iowa State University

- N **Casting.** Current melting practice includes: (a) induction melting in a crucible under a protective atmosphere of argon or in a vacuum, and (b) consumable-electrode arc melting in a reduced-pressure argon-helium atmosphere.
- 7 **Hot working temperature.** 1300 to 1750 F (705 to 955 C)
- 11 **Suited to forming** by machining, turning, grinding, threading, drilling, rolling, swaging, forging, drawing and extruding
- 14 **Sintering temperature.** 1830 F (1000 C) in vacuum
- 15 **Heat treatment.** Calcium-reduced metal is annealed by holding at 1200 to 1380 F for 1 hr and slow cooling. Iodide thorium is similarly annealed at 1110 to 1290 F.

Thulium

See page 1230

Tin

See page 1142

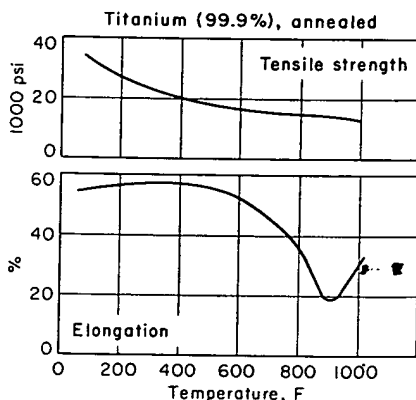
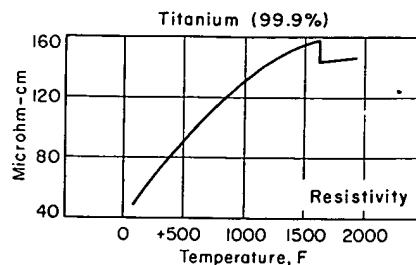
- A 1 **Common name.** Iodide titanium, electrolytic titanium
- B 1 **Typical uses.** Experimentation and research; commercial applications requiring freedom from interstitial alloying elements (oxygen, nitrogen, carbon and hydrogen).
- C 1 **Density at 68 F (20 C).** 0.163 lb per cu in. (4.507 ± 0.005 g per cu cm); beta titanium at 1625 F, 0.156 lb per cu in. (4.35 g per cu cm) (from indirect measurements)
- D 1 **Liquidus temperature.** 3035 ± 18 F (1668 ± 10 C)
- 4 **Boiling point at 1 atmosphere.** 5900 F (3260 C) (estimated)
- 5 **Vapor pressure from 1587 to 1698 K.**
 $\log P = 7.7960 - \frac{24,644}{T} - 0.000227T$
- 6 **Thermal expansion at 68 F (20 C).** 4.67×10^{-6} in./in./°F; at 1832 F, 5.6×10^{-6} in./in./°F (estimated)
- 7 **Thermal expansion in crystallographic direction (calculated from lattice parameters).**

Temperature, F	Direction	Expansion, micro-in./in./°F
68 to 750	Perpendicular to c axis	5.66
68 to 1290	Perpendicular to c axis	6.13
68 to 1290	Along c axis	7.14

- 11 **Specific heat below 13 K (-435 F).**
 C_p (cal/mole/°K) = $8.08 \times 10^{-4} + 0.621 \times 10^{-5}T^3$
 Above room temperature, C_p (cal/mole/°K) = $7.654 - 4.2546 \times 10^{-4}T - 1.236 \times 10^{-7}T^2$

Temp, K	C_p , cal/mole/°K	Temp, K	C_p , cal/mole/°K
50	1.136	500	6.947
75	2.402	550	7.011
100	3.434	600	7.055
125	4.155	650	7.085
150	4.684	700	7.104
175	5.043	750	7.115
200	5.321	800	7.121
225	5.539	850	7.121
250	5.713	900	7.119
275	5.864	950	7.113
298.15	5.976	1000	7.105
300	6.153	1050	7.095
350	6.496	1100	7.084
400	6.711	1150	7.071
450	6.852		

- 13 **Latent heat of fusion.** 5000 cal per mole (estimated)
- 14 **Latent heat of transformation.** 1050 cal per mole (estimated)
- 15 **Latent heat of vaporization.** 112,500 cal per mole (estimated)
- 16 **Thermal conductivity at -400 F.** 6.6 Btu/sq ft/ft/hr/°F
- E 2 **Electrical resistivity at 68 F.** 42.0 microhm-cm; from 68 to 1800 F, see graph.
- 15 **Hall coefficient.** $+1.82 (\pm 0.2) \times 10^{-18}$ volt-cm-amp⁻¹-oersted⁻¹
- 16 **Supraconductivity.** Critical temperature: 0.37 to 0.56 K
- F 5 **Total emissivity.** 0.30 at 1316 F
- G 2 **Magnetic susceptibility at room temperature.** $3.17 (\pm 0.03) \times 10^{-6}$ emu per g
- H 1 **Velocity of sound.** 16,300 ft per sec
- I 1 **General resistance to corrosion.** Better than that of 99.2 and 99.0% Ti alloys (see page 1153)
- J 1 **Crystal structure.** Alpha, hexagonal, close-packed, below 1620 F (882.5 C); beta, body-centered cubic from 1620 F to melting point; alpha: $a = 2.95030$ A, $c = 4.68312$ A, $c/a = 1.5873$; beta: $a = 3.32$ A at 1650 F
- K 1 **Mechanical properties (typical) at room temperature.** Tensile strength, 34,000 psi; 0.2% yield strength, 20,000 psi; elongation in 2 in., 54%; minimum bend radius, less than 1t. See graph for properties at elevated temperatures, top of next column.



Tungsten

Compiled by DALLAS T. HURD†

- B 1 **Typical uses.** As an alloying element in ferrous alloys and tool steels; as filament or sheet in lamps and electron tubes; in missile and space vehicle components (see page 489)
- C 1 **Density at 68 F (20 C).** 19.3 g per cu cm (0.697 lb per cu in.)
- 3 **Compressibility at 68 F (20 C).** 2.8×10^{-7} per megabar. This value is the smallest for any metal.
- D 1 **Melting point.** 6170 F (3410 C)
- 4 **Boiling point.** 10,706 F (5930 C)
- 6 **Thermal expansion.** 4.6 micro-in. per in. per °C at 27 C; 5.2 at 1027 C; 7.3 at 2100 C
- 11 **Specific heat.** 0.033 cal/g/°C
- 12 **Heat capacity.** C_p (cal/deg/mol) = $5.74 + 0.76 \times 10^{-3}t$ ($t = ^\circ K$ over the range from 298 to 2000 K)
- 13 **Heat of fusion.** 44 cal per g
- 15 **Heat of vaporization.** 1150 cal per g
- 16 **Thermal conductivity, cal/cm/sec/°C.**

Value	0	500	1000	2000
	0.397	0.29	0.27	0.25
- 19 **Recrystallization temperature.** 1832 to 2192 F (1000 to 1200 C) for 1 hr, depending on purity and degree of cold work for commercial tungsten, but may range up to more than 3600 F (2000 C) for alloyed or thoriated tungsten.
- 20 **Vapor pressure ($P =$ atmosphere, $t = ^\circ K$).** Solid to melting point, $\log_{10} P = -47.300 - \frac{1.931 \log t + 15.45}{t}$; liquid, $\log P = \frac{-45,600}{t} - 2.01 \log t + 15.25$
- 22 **Entropy at 77 F (25 C).** 8 cal/mol/°C
- E 2 **Electrical resistivity (drawn wire).**

Temp, C	Microhm-cm	Temp, C	Microhm-cm
27	5.65	1827	59.05
327	13.07	2727	90.40
627	21.35	3227	108.5
927	30.26		

- 3 **Work function.** 4.56 ev
- 4 **Electron emission, milliamperes per sq cm.** At 1000 C, 3.2×10^{-10} ; at 2000 C, 3×10^{-2} ; at 3000 C, 84.

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